

6S Return Samples: Assessment of Air Quality in the International Space Station (ISS) Based on Solid Sorbent Air Sampler (SSAS) and Formaldehyde Monitoring Kit (FMK) Analyses

The toxicological assessments of SSAS and FMK analytical results are reported. Analytical methods have not changed from earlier reports. Surrogate standard recoveries from the SSAS tubes were 66-76% for 13C-acetone, 85-96% for fluorobenzene, and 73-89% for chlorobenzene. Post-flight flows were far below pre-flight flows and an investigation of the problem revealed that the reduced flow was caused by a leak at the interface of the pump inlet tube and the pump head. This resulted in degradation of pump efficiency. Further investigation showed that the problem occurred before the SSAS was operated on orbit and that use of the post-flight flows yielded consistent and useful results. Recoveries from formaldehyde control badges were 86 to 104%.

The two general criteria used to assess air quality are the total-non-methane-volatile organic hydrocarbons (NMVOCs) and the total T-value (minus the CO₂ and formaldehyde contributions). The T values will not be reported for these data due to the flow anomaly. Control of atmospheric alcohols is important to the water recovery system engineers, hence total alcohols (including acetone) are also shown for each sample. Octafluoropropane (OFP) is not efficiently trapped by the sorbents used in the SSAS. Because formaldehyde is quantified from sorbent badges, its concentration is also listed separately. These five indices of air quality are summarized below:

Sample Location	Date	NMVOCs (mg/m ³)	OFP ^b (mg/m ³)	T Value ^a (units)	Alcohols (mg/m ³)	Formaldehyde (mg/m ³)
Lab SSAS/For.	09/24/03	19	--	--	5	0.035
SM SSAS/For	09/24/03	16	--	--	5	0.024
Lab SSAS/For.	10/08/03	11	--	--	6	0.048
SM SSAS/For.	10/08/03	13	--	--	4	0.034
Lab SSAS	10/22/03	22	--	--	7	ns ^c
Lab SSAS	10/24/03	19	--	--	7	ns
Acceptable Guideline:		<25	85000	<1	<5	0.050

^a T calculation not done due to flow anomaly.

^b n/a = not in analysis plan

^c ns = no sample available

The table and enclosed analytical results on individual pollutants show that the air quality in general was acceptable for crew respiration through the middle of December 2002. No conclusions can be made about the air quality after that date due to our inability to return air samples from the ISS. Total alcohols are not being consistently controlled to the recently lowered guideline of 5 mg/m³, which was recommended to protect the water recovery system.

Enclosures

1: Analytical Results of Soyuz 6 SSAS Samples

TABLE 1
ANALYTICAL RESULTS OF
SOYUZ 6 SSAS 1011 SOLID SORBENT AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)					
	AA03644 SSAS 1011 Tube 1 Lab 9/23/03@08:15GMT 9/24/03@08:05GMT	AA03645 SSAS 1011 Tube 2 Service Mod 9/24/03@08:10GMT 9/25/03@09:00GMT	AA03646 SSAS 1011 Tube 3 Lab 10/7/03@16:30GMT 10/8/03@17:00GMT	AA03647 SSAS 1011 Tube 4 Service Mod 10/8/03@17:00GMT 10/9/03@16:45GMT	AA03648 SSAS 1011 Tube 5 Lab 10/22/03@15:50GMT 10/23/03@14:35GMT	AA03650 SSAS 1011 Tube 7 Lab 10/24/03@17:22GMT 10/25/03@18:05GMT
TARGET COMPOUNDS (TO-14/POLAR)***						
FREON 12	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
CHLOROMETHANE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
FREON 114	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
METHANOL	0.4	0.4	0.5	0.3	0.4	0.3
ACETALDEHYDE	0.4	0.4	0.5	0.4	0.5	0.5
VINYL CHLORIDE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
BROMOMETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
ETHANOL	4	4	5	3	6	6
CHLOROETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
ACETONITRILE	TRACE	TRACE	0.1	TRACE	TRACE	TRACE
PROPENAL	< 0.04	< 0.04	< 0.04	< 0.04	< 0.05	< 0.04
ACETONE	0.2	0.2	0.3	0.2	0.3	0.3
PROPANAL	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
2-PROPANOL	0.2	0.2	0.2	0.1	0.2	0.2
FREON 11	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
FURAN *	< 0.1	0.003	0.003	0.001	< 0.1	0.003
ACRYLONITRILE	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
PENTANE	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
2-METHYL-2-PROPANOL	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
METHYL ACETATE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	TRACE
1,1-DICHLOROETHENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
DICHLOROMETHANE	0.1	TRACE	0.1	TRACE	0.10	TRACE
3-CHLOROPROPENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
FREON 113	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
N-PROPANOL	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
1,1-DICHLOROETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
BUTANAL	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-BUTANONE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
CIS-1,2-DICHLOROETHENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-METHYLFURAN	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
ETHYL ACETATE	TRACE	TRACE	TRACE	TRACE	0.11	0.2
HEXANE	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
CHLOROFORM	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-BUTENAL	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,2-DICHLOROETHANE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
1,1,1-TRICHLOROETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
N-BUTANOL	TRACE	TRACE	TRACE	TRACE	0.10	TRACE
BENZENE *	0.01	0.01	0.01	0.01	0.01	0.01
TETRACHLOROMETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-PENTANONE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
PENTANAL	TRACE	TRACE	TRACE	TRACE	TRACE	< 0.1
1,2-DICHLOROPROPANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,4-DIOXANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
TRICHLOROETHENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2,5-DIMETHYLFURAN*	< 0.1	0.002	< 0.1	< 0.09	< 0.1	0.002
4-METHYL-2-PENTANONE	< 0.1	TRACE	TRACE	< 0.09	< 0.1	TRACE
CIS-1,3-DICHLOROPROPENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-PENTENAL	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
TRANS-1,3-DICHLOROPROPENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,1,2-TRICHLOROETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
TOLUENE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
HEXANAL	< 0.1	TRACE	< 0.1	< 0.09	< 0.1	< 0.1
MESITYL OXIDE	< 0.1	TRACE	TRACE	< 0.09	< 0.1	TRACE
1,2-DIBROMOETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
BUTYL ACETATE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
TETRACHLOROETHENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
CHLOROBENZENE	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
ETHYLBENZENE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
META+PARA-XYLENES	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
2-HEPTANONE	< 0.1	TRACE	TRACE	TRACE	TRACE	TRACE
CYCLOHEXANONE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
HEPTANAL	< 0.1	TRACE	TRACE	TRACE	< 0.1	TRACE
STYRENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,1,2,2-TETRACHLOROETHANE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
ORTHO-XYLENE	0.1	0.1	TRACE	TRACE	0.12	TRACE
1,3,5-TRIMETHYLBENZENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,2,4-TRIMETHYLBENZENE	< 0.1	TRACE	TRACE	< 0.09	< 0.1	< 0.1
1,3-DICHLOROBENZENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,4-DICHLOROBENZENE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
1,2-DICHLOROBENZENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
1,2,4-TRICHLOROBENZENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
HEXACHLORO-1,3-BUTADIENE	< 0.2	< 0.2	< 0.2	< 0.1	< 0.2	< 0.2

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)					
	AA03644 SSAS 1011 Tube 1 Lab 9/23/03@08:15GMT	AA03645 SSAS 1011 Tube 2 Service Mod 9/24/03@08:10GMT	AA03646 SSAS 1011 Tube 3 Lab 10/7/03@16:30GMT	AA03647 SSAS 1011 Tube 4 Service Mod 10/8/03@17:00GMT	AA03648 SSAS 1011 Tube 5 Lab 10/22/03@15:50GMT	AA03650 SSAS 1011 Tube 7 Lab 10/24/03@17:22GMT
	9/24/03@08:05GMT	9/25/03@09:00GMT	10/8/03@17:00GMT	10/9/03@16:45GMT	10/23/03@14:35GMT	10/25/03@18:05GMT

TARGET COMPOUNDS (TOXIC)

1,3-BUTADIENE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
ETHYLENE OXIDE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
CARBON DISULFIDE	TRACE	TRACE	TRACE	TRACE	TRACE	TRACE
2-METHYL-2-PROPENAL	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
3-BUTEN-2-ONE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
2-ETHOXYETHANOL	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
DIMETHYLDISULFIDE	< 0.1	< 0.1	< 0.1	< 0.09	< 0.1	< 0.1
OCTAMETHYLCYCLOTETRAISILOXANE	7	1	1	1	2	2

NON-TARGET COMPOUNDS

PROPENE	0.01	0.01	0.02	0.01	0.01	0.009
CARBONYL SULFIDE	0.07	0.06	0.09	0.08	0.08	0.09
PROPANE	0.008	0.007	0.01	0.007	0.007	0.007
1,3-DIOXOLANE	0.02	0.02	0.03	0.02	0.03	0.03
HEXAMETHYLCYCLOTRISILOXANE	5	7	1	6	10	7.0
LIMONENE	0.08	0.07	0.04	0.03	0.04	0.04
DECAMETHYLCYCLOPENTASILOXANE	0.5	0.7	0.2	0.5	0.8	0.6

TOTAL ALCOHOLS PLUS ACETONE	5	5	6	4	7	6
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**TOTAL CONCENTRATION
(NON-METHANE HYDROCARBONS)**

19	16	11	13	22	19
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< : Values are less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only. Calculations are based on one-half of the laboratory reported detection limit for each SSAS tube.

(See individual sheets for detection limits)

***Measurements of Target Compounds are calibrated by mid-point continuing calibration relative response factors. Linearity verified with initial calibration.

* Detection limit changed to 0.0 for **bold** values.